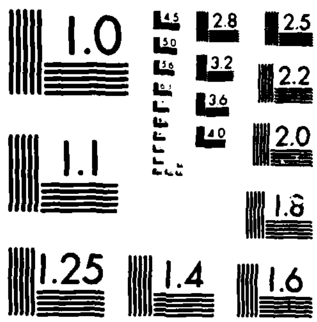
AD-A163 650 EFFECTS OF CONVERGENCE ZONE MULTIPATH ON CROSSCORRELATION(U) NAVAL UNDERWATER SYSTEMS CENTER NEW LONDON CT NEW LONDON LAB W S HAUCK ET AL. 07 JAN 86 1/1

UNCLASSIFIED NUSC-TD-7563 F/G 20/1 NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

12

NUSC Technical Document 7563

7 January 1986

AD-A163 650

Effects of Convergence Zone Multipath on Crosscorrelation

Walter S. Hauck III
E. Richard Robinson
Azizul H. Quazi
Surface Ship Sonar Department

Naval Underwater Systems Center
Newport, Rhode Island / New London, Connecticut

Approved for public release; distribution unlimited.

PREFACE

The work reported in this document was completed under NUSC Project No. 733P32, Principal Investigator Dr. A. H. Quazi (Code 3314) and Project No. A65000, "EVA Support for Shipboard Sonar," Principal Investigator, B. F. Cole (Code 33A). The sponsoring activity is the Naval Sea Systems Command with funding provided by SEA-63D, Program Manager D. E. Porter.

The authors would like to thank P. Herstein (Code 33A3) and H. Weinberg (Code 3332) for their comments and suggestions during the course of this work.

Reviewed and Approved: 7 January 1986

L. Freeman
Head, Surface Ship Sonar Department

The authors of this document are located at the
Naval Underwater Systems Center, New London Laboratory,
New London, Connecticut 06320.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) TD 7563	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Underwater Systems Center 6b. OFFICE SYMBOL (If applicable) 3331	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) New London Laboratory New London, Connecticut 06320	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Naval Sea Systems Command 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Washington, DC 20362	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. A65000 · PROJECT NO. · TASK NO. · WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
EFFECTS OF CONVERGENCE ZONE MULTIPATH ON CROSSCORRELATION

12. PERSONAL AUTHOR(S)
Walter S. Hauck III, E. Richard Robinson, Azizul H. Quazi

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Presentation	FROM ______ TO ______	1986 January 7	18

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Acoustic Multipath, Convergence Zones, Crosscorrelation,

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This document contains the slide presentation entitled "Effects of Convergence Zone Multipath" given at the 110th meeting of the Acoustical Society of America 4-8 November 1985, in Nashville, Tennessee.

Recent work by Hauck [1] indicates autocorrelation processing may be adversely affected by the large number of acoustic rays from a source within a convergence zone. The object of the current study is to examine the effect of CZ multipath on cross-correlation of frequency hopped pulses. The sensitivity of the correlation to source or receiver depth and the location of the source within a convergence zone is examined using the Generic Sonar Model [2].

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Walter S. Hauck III	22b. TELEPHONE (Include Area Code) (203) 440-6000 22c. OFFICE SYMBOL Code 3331

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

EFFECTS OF CONVERGENCE ZONE MULTIPATH ON CROSSCORRELATION

-- First Viewgraph, please (1). --

CONVERGENCE ZONE CROSSCORRELATION

PROBLEM: UNDERSTAND AND PREDICT THE EFFECTS OF CZ MULTIPATH ON THE CROSSCORRELATION OF WIDEBAND SIGNALS

APPROACH: USE MODIFIED GENERIC SONAR MODEL

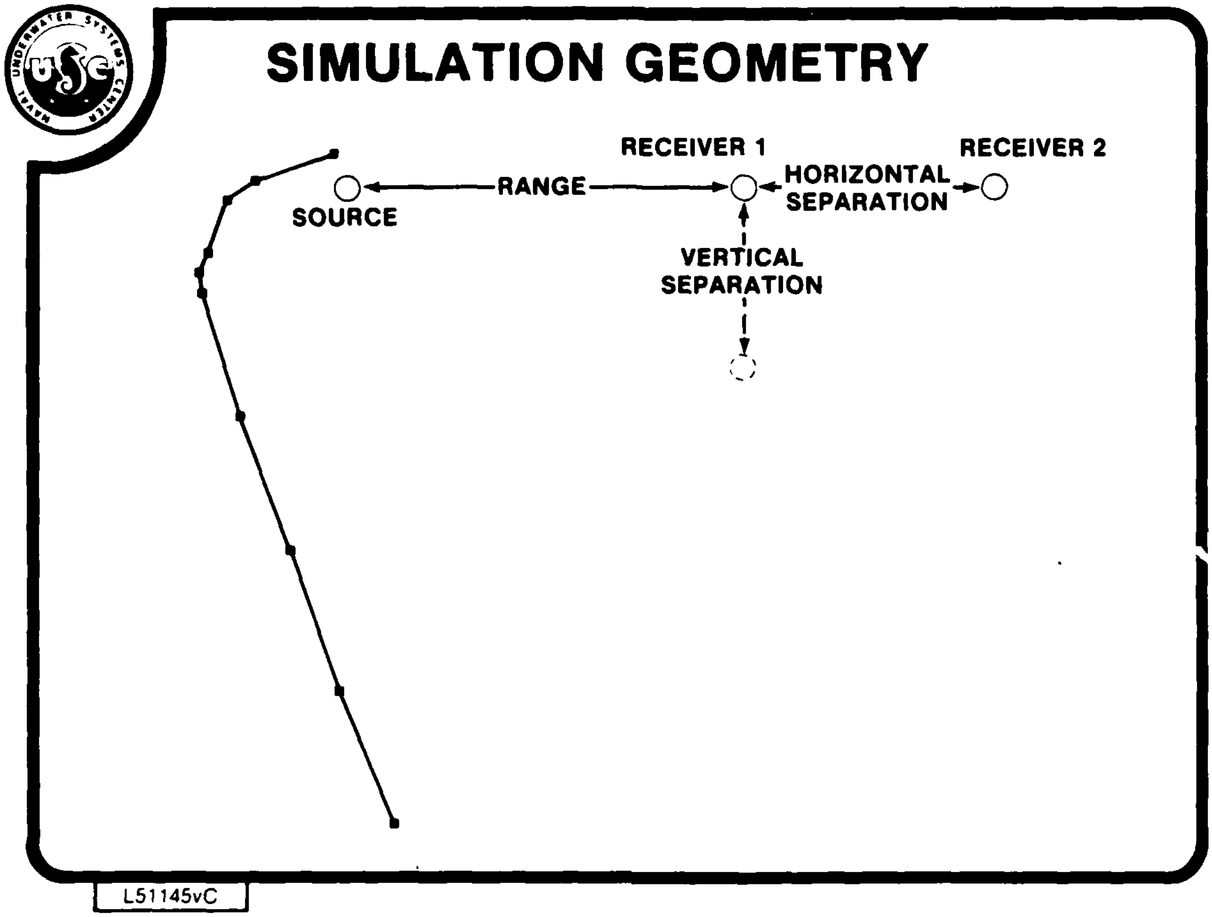
- SIMULATE CROSSCORRELOGRAMS FOR A VARIETY OF SOURCE/RECEIVER GEOMETRIES
- RELATE CZ RAY STRUCTURE TO SIMULATED CORRELOGRAM

L51145uC

Viewgraph 1

The objective of this work is to characterize the effects of convergence zone multipath on the correlation of signals between widely spaced sensors. A modified version of the Generic Sonar Model was used to simulate the correlograms shown in this study.

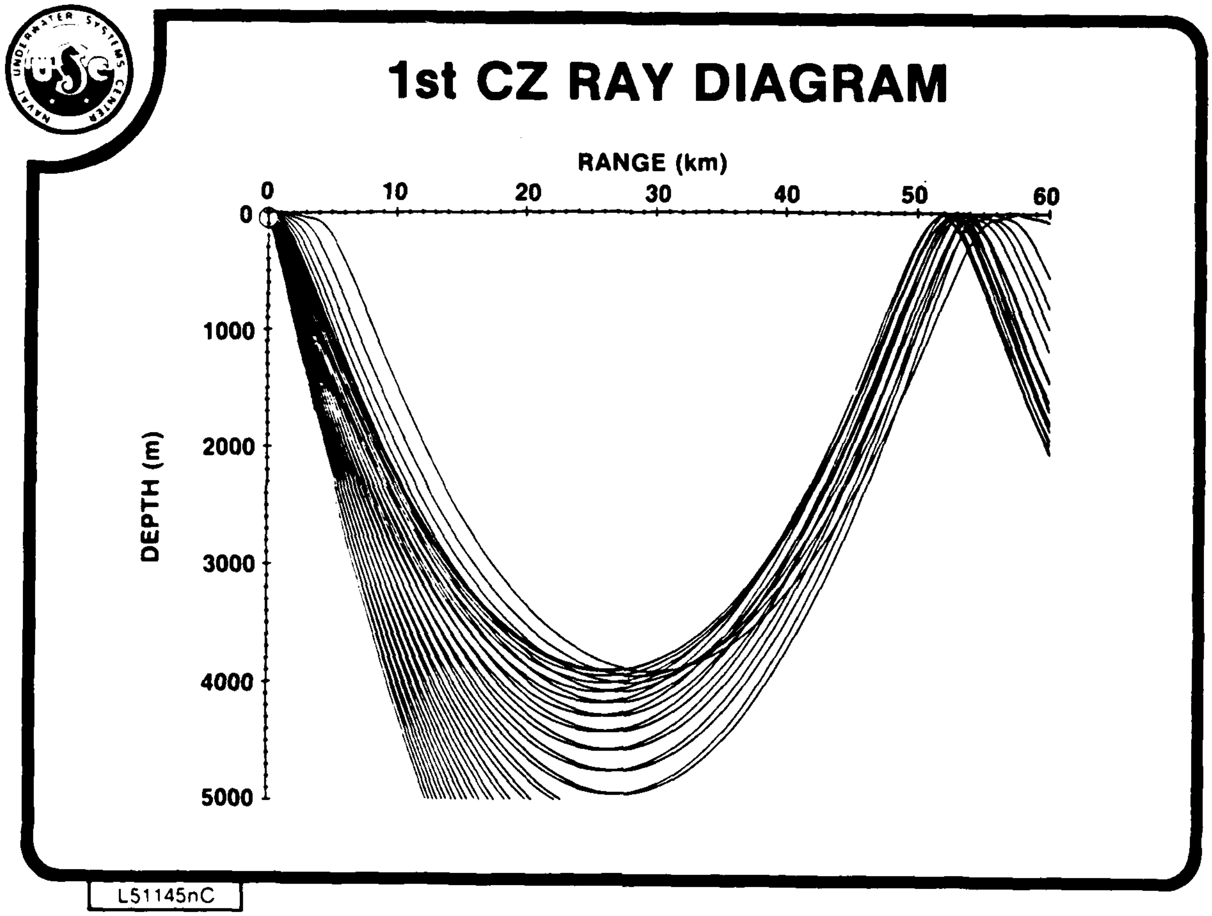
-- Next Viewgraph, please (2) --



Viewgraph 2

Two source receiver geometries will be discussed. The first is an end-fire configuration, with both source and receivers in a horizontal line. Horizontal range is measured between the source and receiver 1. For the second geometry, both receivers are located at the same horizontal range but at different depths.

-- Next Viewgraph, please (3). --

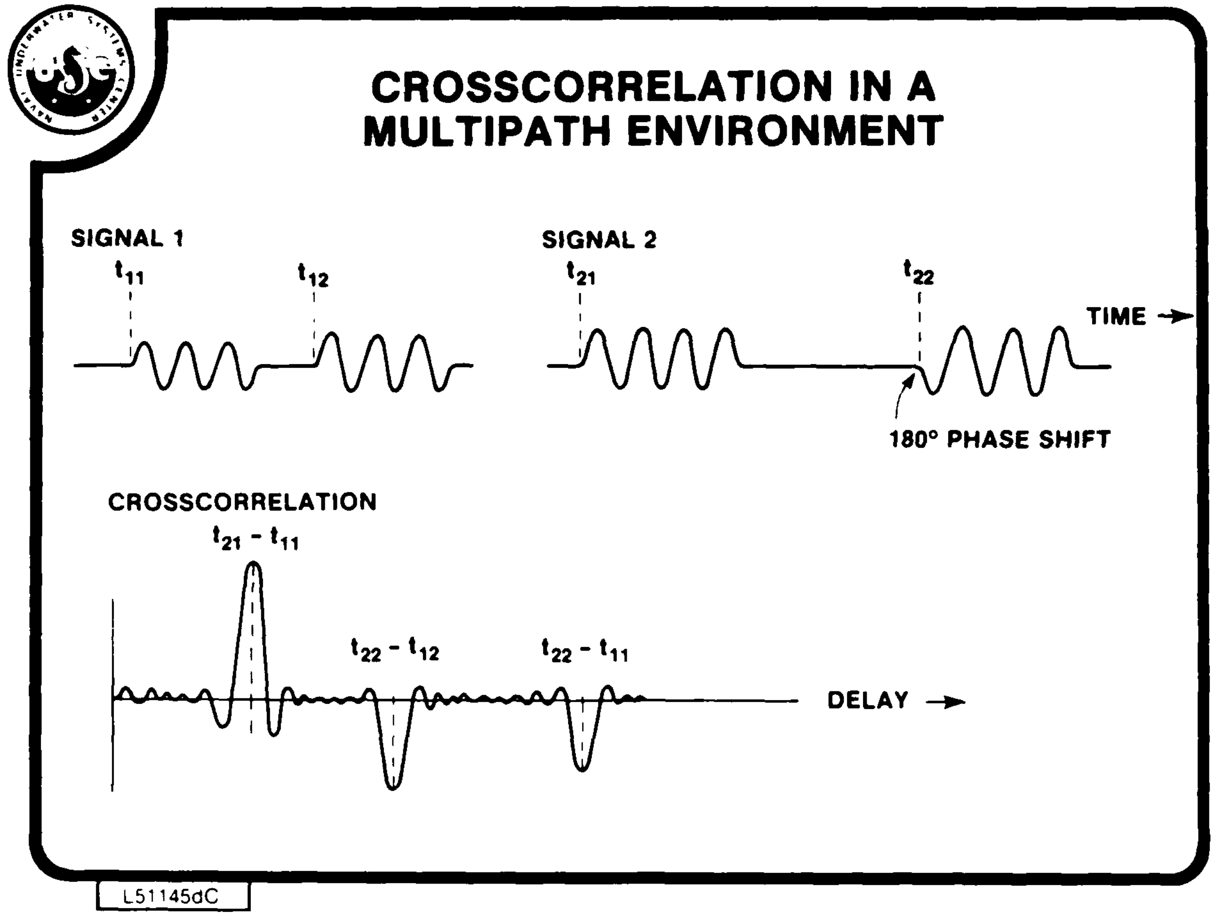


Viewgraph 3

This viewgraph provides a brief review of convergence zone propagation. A CZ is formed by many rays which, due to the ocean sound speed profile, refract at depth and focus in a small well-defined region. The acoustic intensity in the CZ is greatly increased by this focusing, analogous to the focusing of light through a lens.

-- Next Viewgraph, please (4)

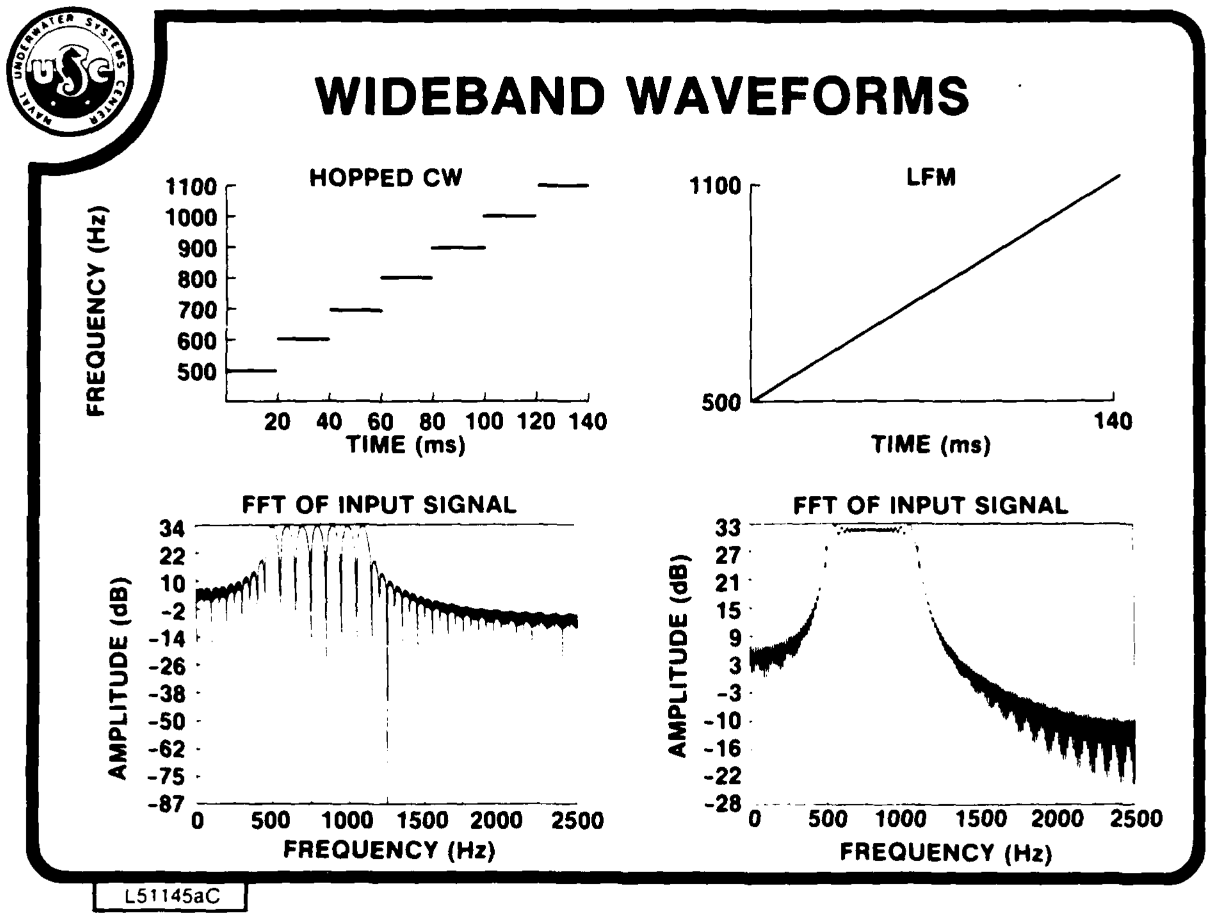
Accesion For		
NTIS CRA&I	☑	
DTIC TAB	☐	
Unannounced	☐	
Justification		
By		
Distribution /		
Availability Codes		
Dist	Avail and / or Special	
A-1		



Viewgraph 4

The effect of multiple ray paths on the crosscorrelation function is depicted in the viewgraph. The signal at receiver 1 is formed by two ray arrivals with travel times T_{11} and T_{12}. Similarly, The signal at receiver 2 has arrivals at T_{21} and T_{22}, with the second arrival shifted by 180 degrees, as if reflected from the ocean surface. The crosscorrelation function has peaks at each of the travel time differences between the arrivals at receiver 1 and receiver 2. The polarity at the peak is determined by the phase between the arrivals, positive for like phase, negative for opposite phase. Note the correlogram shows only three peaks, not four, as we have assumed the smallest travel time difference is less than zero. The width of each peak is determined by the bandwidth of the received signals, the smaller the bandwidth the wider the correlation peak.

-- Next Viewgraph, please (5) --



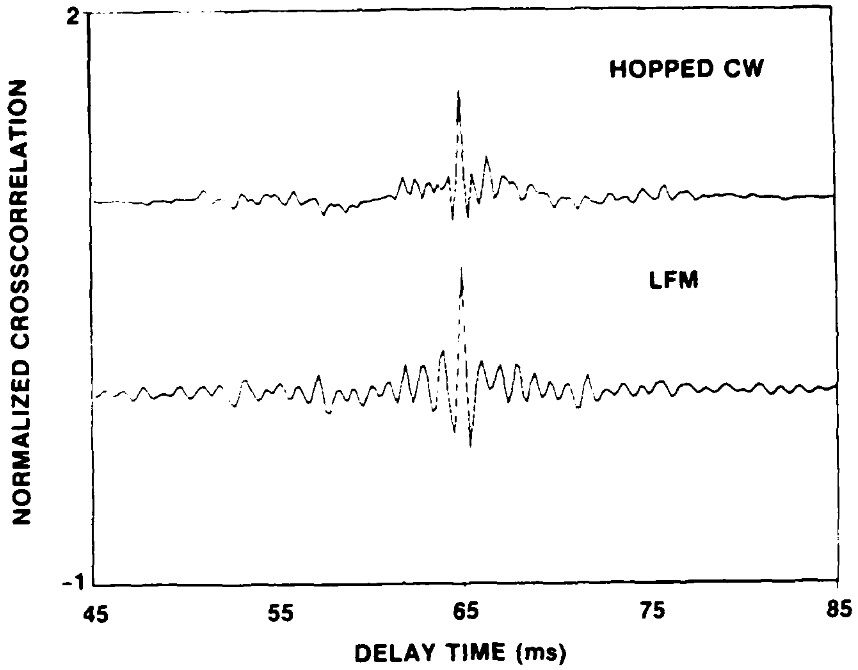
Viewgraph 5

The received signals used in this study are shown in this viewgraph. Both are broadband waveforms and thus should have relatively narrow correlation peaks. The first signal consists of seven 20 millisecond pulses. The frequency of each successive pulse is 100 Hz greater than the preceding pulse, between 500 and 1100 Hz. In the signa' magnitude spectrum, the seven frequencies are clearly visible. The type of signal is contrasted with the linear FM sweep. The spectrum is similar, but flatter across the 500 - 1100 Hz band.

-- Next Viewgraph, please (6). --

1st CZ CROSSCORRELATION SOURCE COMPARISON

RANGE = 54 km



L51145hC

Viewgraph 6

The correlation function of the two signals is also similar. The top trace is for the hopped sequence; the bottom, for the LFM. While the correlation functions are similar, it is important to note that the LFM has a larger correlation peak than the hopped sequence.

-- Next Viewgraph, please (7). -

SIMULATION PARAMETERS

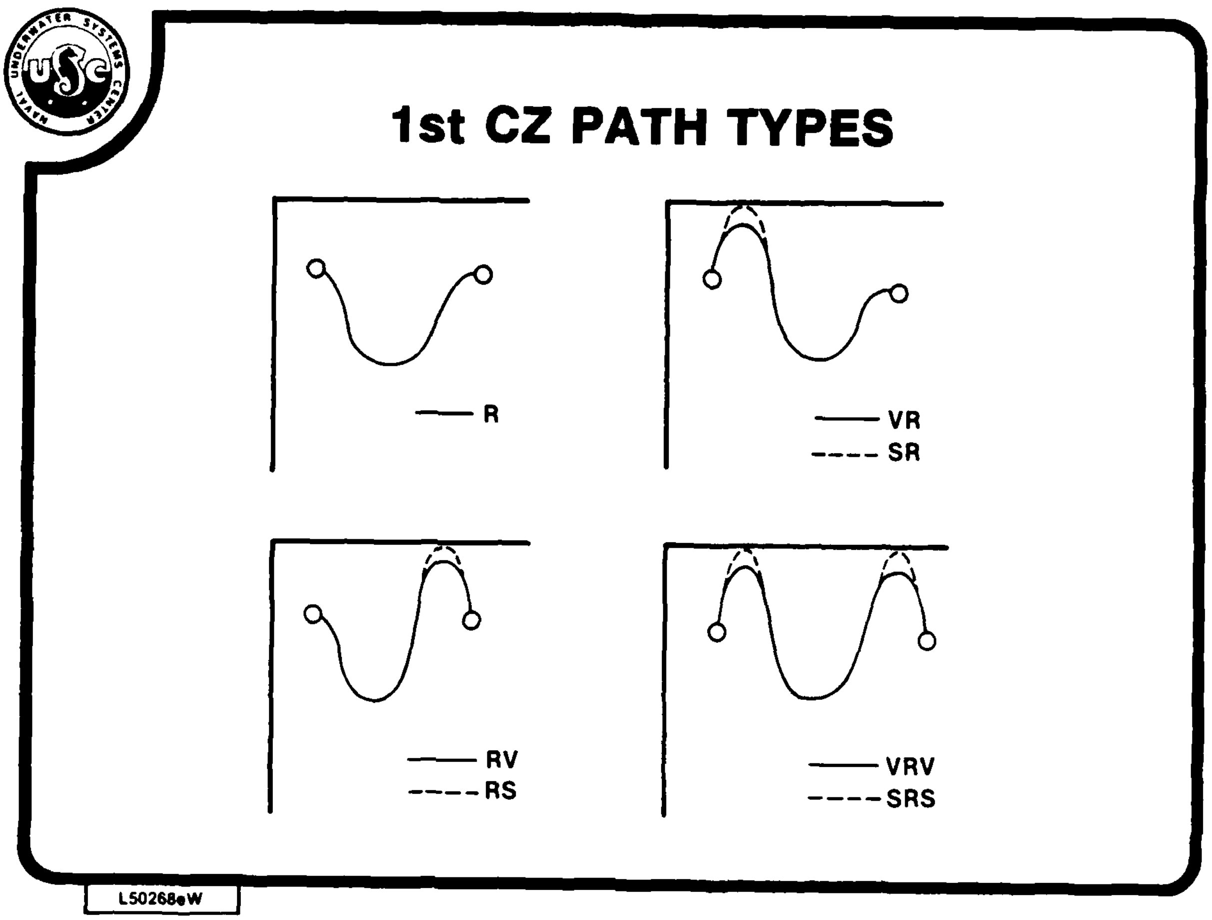
- FAME EIGENRAY MODEL
- RECEIVED SIGNAL BANDWIDTH 100-2500 Hz
- SOURCE/RECEIVER DEPTHS 20-100 M
- HORIZONTAL RECEIVER SEPARATION 100-1000 M
- VERTICAL RECEIVER SEPARATION 0-150 M
- SINGLE CZ SOUND SPEED PROFILE

L51145cC

Viewgraph 7

Two additional parameters not included in this figure are (1) the signal-to-noise ratio for the received signals is in excess of 100 dB, and (2) since we are interested in isolating the effects of acoustic miltipath, only the signal magnitude spectra, amplitude vs. frequency, were input to the GSM. No signal phase information was used.

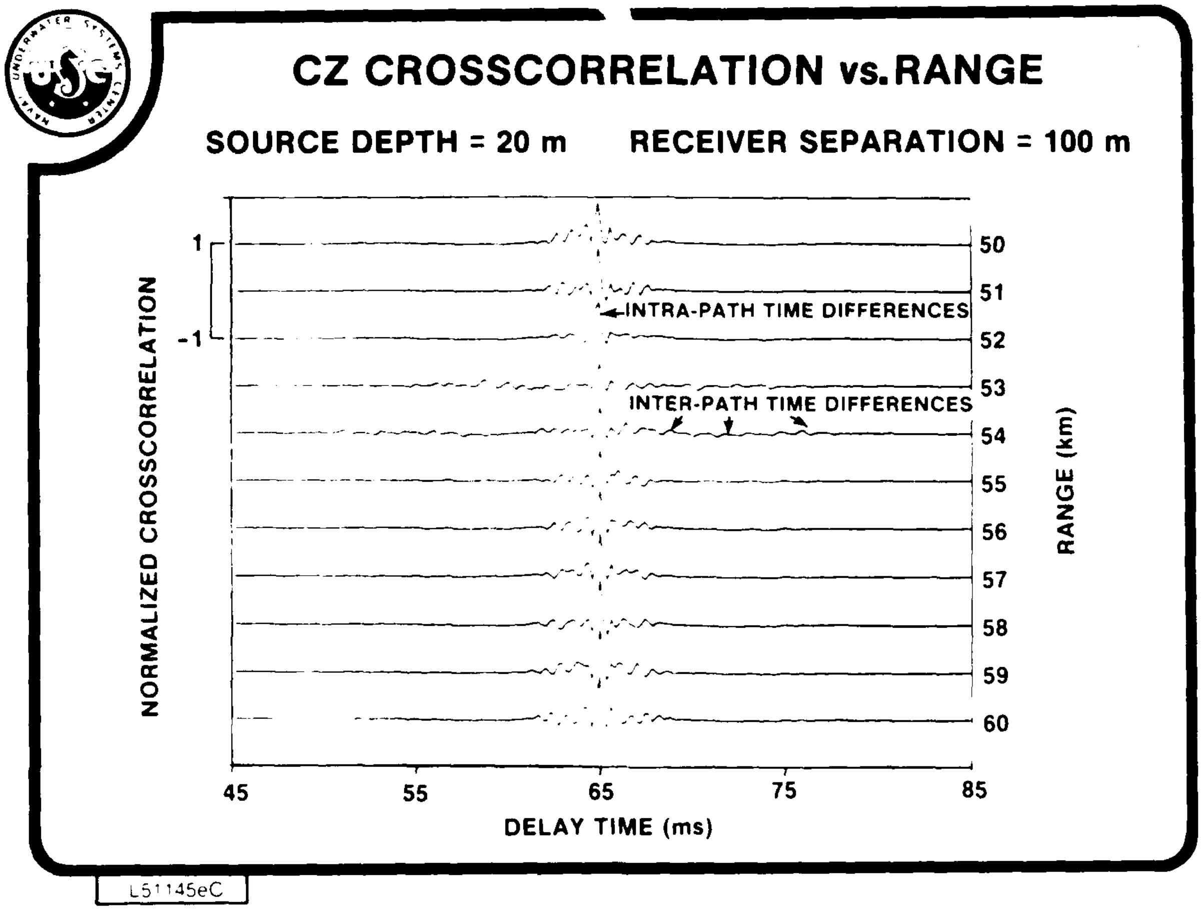
-- Next Viewgraph, please (7). --



Viewgraph 8

To interpret the crosscorrelation function, it is important to categorize the types of rays which make up the CZ. In this viewgraph, we see four ray types are possible. Three of the four may be further subdivided by their interaction with the sea surface; either a refraction below the surface, shown as the solid line, or a surface reflection, shown as a dashed line. Also, since we are concerned with time differences, we will define two types of travel time differences: intra- and interpath. Intrapath differences are the time differences between the same ray types to each receiver, say an R path at receiver 1 and an R path to receiver 2. Interpath travel time differences are formed from dissimilar path types. It is also important to note that several paths of a single type may be present in the CZ. Thus, there is the opportunity for many intrapath time differences forming from each path type.

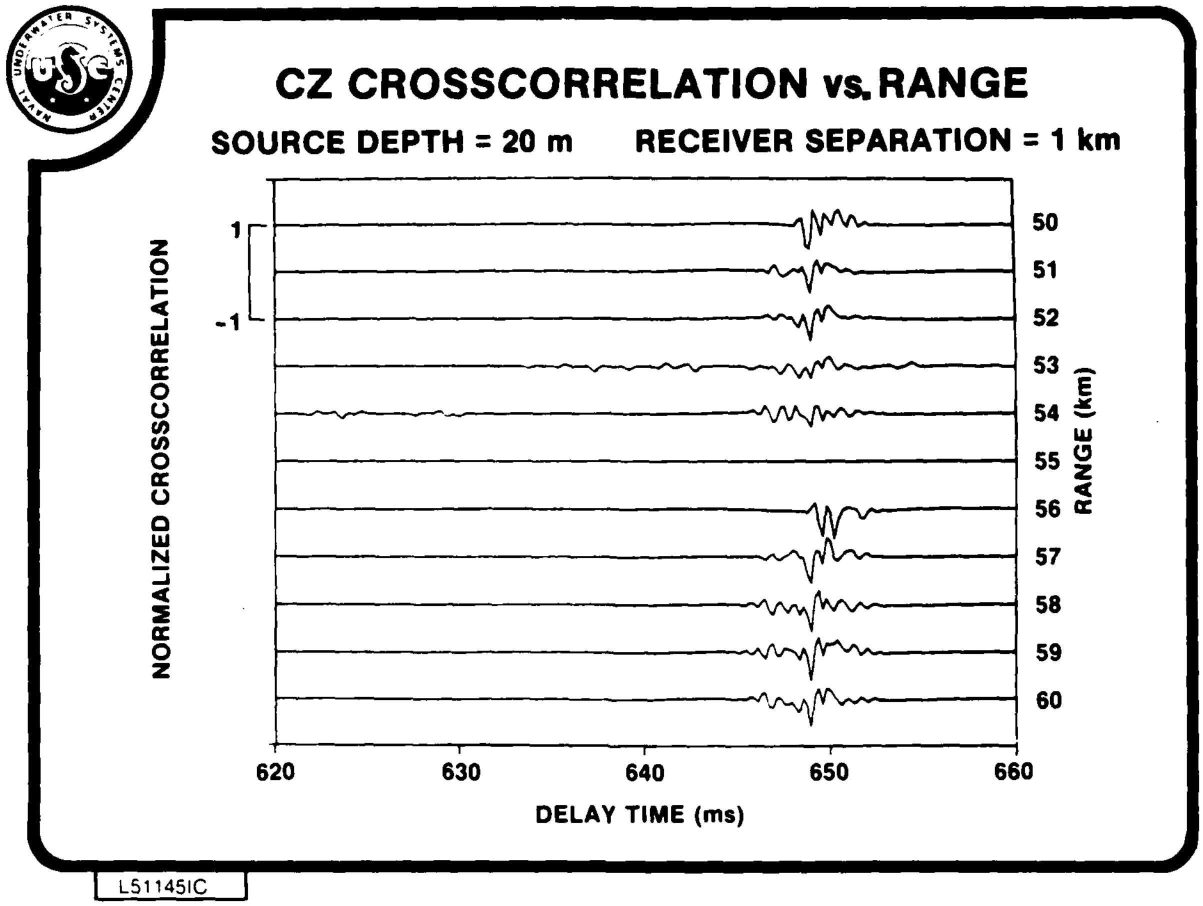
--Next Viewgraph, please (9). --



Viewgraph 9

This figure shows the crosscorrelation function vs. range across the 1st CZ. The horizontal separation between receivers is 100 m. The ranges 50 - 51 km correspond to both receivers just before the start of the CZ. At 52 km, both receivers are near the front of the CZ, and the travel time differences are clustered near the bulk time delay, 64 ms. Because of the relatively small receiver separation, the eigenray structure between the receivers are very similar. Thus all the intrapath time differences align to form a single large correlation peak. Around the main correlation peak are smaller peaks caused by interpath time differences, which show minor changes as the receivers move across the convergence zone.

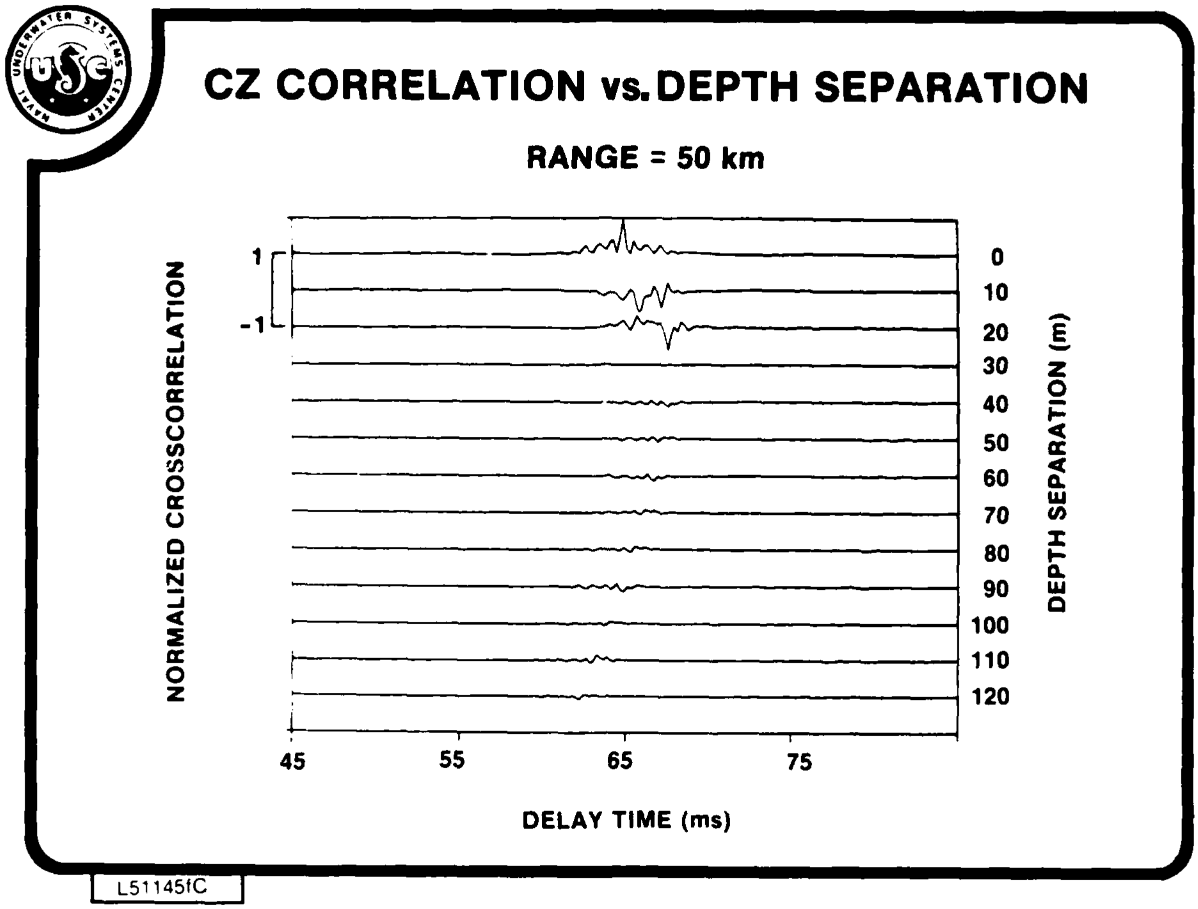
-- Next Viewgraph, please. (10). --



Viewgraph 10

The figure is again crosscorrelation vs. range, but for a receiver separation at 1 km. Note the bulk time delay has been greatly increased, as expected, and no range single correlation peak is evident. For large receiver separations, the eigenray structures are different, and can be dramatically different. Now the intrapath time differences do not align exactly but are spread out by 3 - 5 ms. Note the straight line at a range of 55 km appears to be an anomaly and should be ignored.

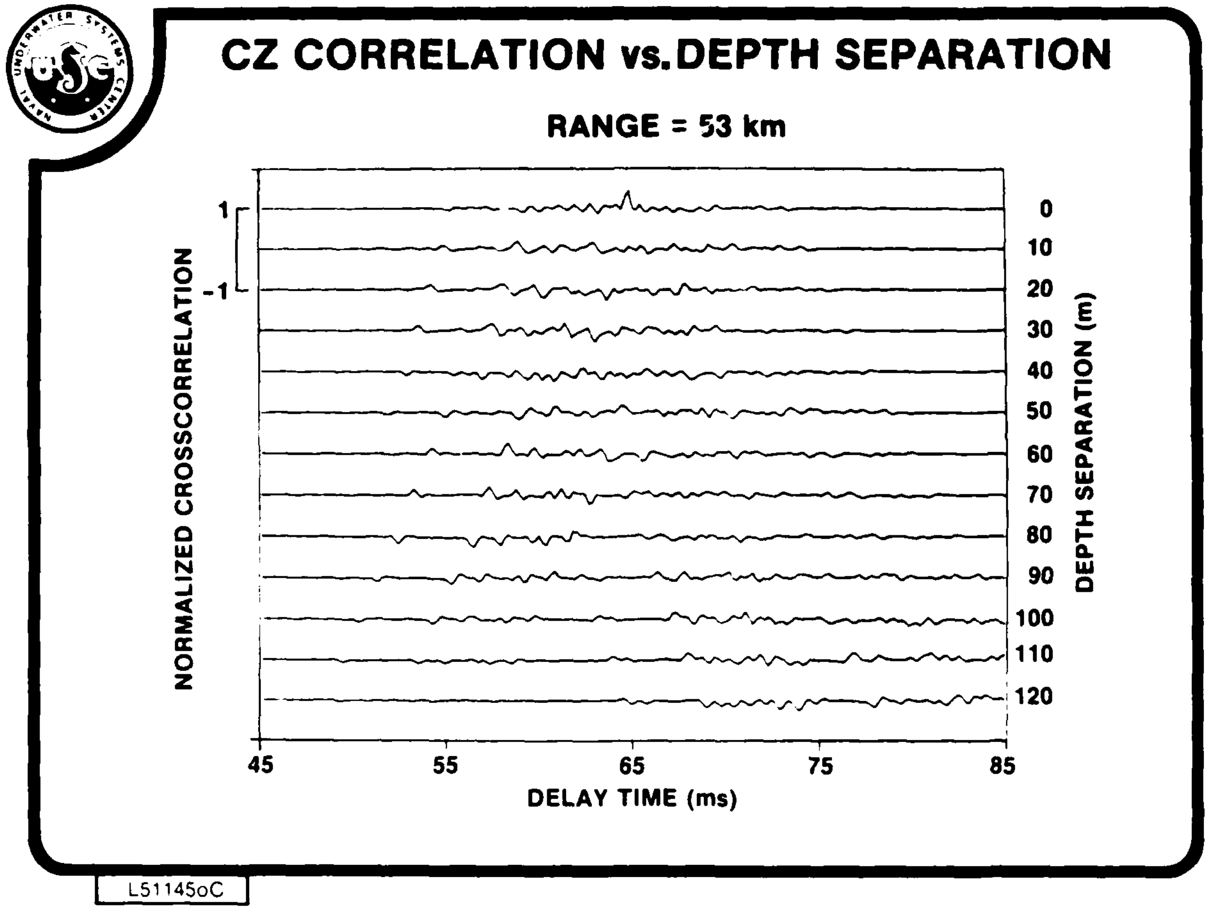
-- Next Viewgraph, please (11). --



Viewgraph 11

The figure presents the autocorrelation function vs. increasing vertical receiver separation. The range of 50 km again corresponds to the two receivers just outside the front of the 1st CZ. As receiver 2 drops in depth, the correlation function quickly degrades and is almost nonexistent when the second receiver is just inside the first caustic, shown on the viewgraph as a depth difference of 30 m. These changes in the correlation function for very small receiver depth differences are an indication that the eigenray structure is more variable in depth than in range.

-- Next Viewgraph, please (12). --



Viewgraph 12

A less dramatic example is when both receivers are inside the CZ initially. Here all the travel time differences spread apart as the second receiver drops, with many small correlation peaks present. As the second receiver drops below 50 m, the eigenrays change from surface-reflected to near surface-refracted types, and the interpath correlation peaks diminish. The set of peaks moving to greater delays are interpath time differences for ray types which still are common to both receivers.

-- Next Viewgraph, please (13). --

OBSERVATIONS

- CORRELATION OF HOPPED CW SEQUENCE COMPARES FAVORABLY WITH CORRELATION OF LFM
- DIFFERENCES IN EIGENRAY STRUCTURE FOR HORIZONTAL SENSOR SEPARATIONS OF GREATER THAN 100 m RESULT IN DEGRADATION OF CORRELOGRAM PEAKS
- SMALL VERTICAL SEPARATIONS SPREAD CORRELOGRAM OVER GREATER RANGE OF TIME DELAYS

L51145pC

Viewgraph 13

Some observations to be drawn from this study are (1) the specific type of wideband signal used has only a small impact on the correlation function (The differences between the hopped cw and LFM are due primarily to the different effective time-bandwidth products caused by "scalloping" in the hopped signal spectrum); (2) receiver separation yield diminished crosscorrelation when the eigenray structures between the two becomes appreciably different. This occurs in both the horizontal and vertical planes, with about 10 times the variabilty in the vertical.

This work is continuing toward including signal phase effects, which will cause much larger differences between the correlation of different waveforms with similar bandwidths and simulate the two-way propagation effects on the active transmission of these wideband signals.

REFERENCES

1. W. S. Hauck III, Autocorrelation Processing in Convergence Zones, NUSC Technical Document 7409, 30 May 1985.

2. H. Weinberg, Generic Sonar Model, NUSC Technical Document 5971D, 6 June 1985.

INITIAL DISTRIBUTION LIST

Addressee	No. of Copies
DARPA (CDR K. Evans)	1
ONT, Code 0731 (T. Kooij, T. Warfield)	2
CNO (OP-095, -098, -952D (CDR H. Dantzler)	3
NAVSEASYSCOM (SEA-63R (D. Porter), PMS-409 (Ying Yam), PMS-411)	3
NAVELECSYSCOM (612 (R. Mitnick, B. Ogg)	2
NOSC (C. Persons)	1
DREP (D. Thomson)	1
NSWC (R. Stevenson, E. Hein, Library)	2
NORDA (113 (R. Martin , R. Farwell, W. Carey)	3
DIA	1
ARL/UT (C. Penrod)	1
ARL/PSU (C. Ackerman, A. Stuart, Library)	3
DTIC	12

END

FILMED

3-86

DTIC